EMC

EXECUTIVE SUMMARY

ENERGY ENGINEERING ANALYSIS PROGRAM (EEAP)

WILLIAM BEAUMONT ARMY MEDICAL CENTER FORT BLISS, TEXAS

Prepared for

UNITED STATES ARMY CORPS OF ENGINEERS FORT WORTH DISTRICT FORT WORTH, TEXAS

Under

CONTRACT NO. DACA 63-83-C-0183

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FORT BLISS, TEXAS

August 1984

Prepared for

United States Army Engineer District,
Fort Worth
Corps of Engineers
Fort Worth, Texas

Under

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Prepared by

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EXECUTIVE SUMMARY
ENERGY ENGINEERING ANALYSIS PROGRAM
WILLIAM BEAUMONT ARMY MEDICAL CENTER
FORT BLISS, TEXAS

INTRODUCTION

The purpose of this study was to perform a complete energy audit and analysis of William Beaumont Army Medical Center (WBAMC) under the guidelines of the Energy Engineering Analysis Program (EEAP) at Fort Bliss in El Paso, Texas. Project documentation was prepared for all economically feasible energy conservation opportunities (ECOs).

A summary of the Scope of Work is as follows:

- o Perform a complete energy audit and analysis for the entire hospital facility.
- o Develop a metering plan for the facility.
- o Identify all ECOs and perform complete evaluations, including low cost/no cost items.
- o Prepare project documentation for all economically justifiable ECOs.
- o List and prioritize all recommended energy conservation projects.
- o Prepare a comprehensive report which documents the work accomplished, the results, and the recommendations.

WBAMC is part of the overall Fort Bliss complex in El Paso, Texas. WBAMC was designed in 1969 and constructed during 1970 and 1971. Two major modifications have occurred since that time. First, in 1978 seismic and fire safety modifications, and upgrades to the mechanical and electrical systems were made. Second, in 1982 the Omar Bradley Building (Annex) was opened, and a 10,280 sq. ft., 296-collector solar energy system was added for domestic hot water use.

Presently, WBAMC has an in-patient capacity of 474 beds and serves an average of 2,582 people a day through its outpatient clinics. In carrying out its present functions, WBAMC employs 2,591 personnel, of which 87% (or 2254) work the day shift, 181 work the night shift, and 156 work the swing shift.

Central systems for hospital utility services include a 43,530 lb/hr steam plant for heating and hot water service, 1800 tons of refrigeration chillers for air conditioning, and 1100 kW of emergency generators. Electricity is fed to WBAMC from Fort Bliss. A total of nineteen central air handling units located on the first and fifth floors handle the heating, ventilating, and air

conditioning needs of the hospital. Thirteen air handling units serve the Omar Bradley Building. An operating and maintenance staff of 22 are responsible for day-to-day operations of the mechanical and electrical systems of WBAMC.

ENERGY CONSUMPTION

Historical Energy Use

Available energy data for the William Beaumont Army Medical Center was obtained and evaluated for FY81, FY82, and FY83. Baseline energy usage data for FY75 was not available. Energy used by WBAMC consisted of electricity and natural gas. Both sources are received through Fort Bliss; i.e., bulk quantities for the entire Fort Bliss Army complex are received and metered at one point, then submetered for service to WBAMC.

Historical energy usage data collected encompassed both the periods before and after the Omar Bradley Building (Annex) was placed in service. Since the Annex opened in May 1982, the energy data from May 1982 to May 1983 represents an actual metered data base of the entire facility. Annual summary of energy use is:

Period	Electricity (kWh/yr)	Natural Gas (kcf/yr)	Total Source Energy (MBtu/yr)
FY1981	20,340,600	104,602	343,796
FY1982	21,970,200	138,970	398,132
May '82 to May '83	22,335,600	174,402	438,901

Source: Fort Bliss DEH Office

The May 1982 to May 1983 metered energy usage data is the basis used to validate the model data base energy use obtained from computer simulation.

Energy Data Base Analysis

Several steps were included in performing the energy data base analysis:

- o Air flow measurements were taken on all systems during the field survey and evaluated afterward to determine if systems were balanced and operated as originally designed.
- o Performance data was collected on central boilers and chillers and evaluated to determine variations from design performance.

- Based on the findings of the field survey, WBAMC was evaluated using the ESP-II Building Loads and System Analysis computer program. WBAMC was broken down into several segments for ease in loading and evaluating computer output results as described in Section 4.5 of the report.

The energy data base for WBAMC was established by performing computer simulations for various areas of the complex based on data gathered during the field survey, discussions with key operating personnel at WBAMC, and monitoring systems performance. The results were consolidated and compared with 12 months of actual metered data. The results of the analysis are within 3% of actual metered data, as summarized below and shown in more detail on Table ES.1 on the following page.

Comparison of Energy Data Base with Metered Data

Category	Fossil Fuel (MBtu/yr)	Electricity (kWh/yr)
Heating	55,538	--
Cooling	30,164	2,652,355
Fans	--	5,849,182
Lighting	--	4,506,029
Domestic Hot Water	25,200	--
Equipment (general)	6,764	4,731,217
Central Plant Use	5,826	2,777,035
Conversion, Transformer, Distribution Losses	45,497	1,215,090
Miscellaneous	6,000	610,000
Total (Calculated)	174,989	22,340,908
Total (Metered)	179,812	22,335,600

TABLE ES.1

William Beaumont Army Medical Center
Data Base Energy Usage Breakdown by Categories

	Electricity (kWh/yr)			
	Beaumont Bldg.	Bradley Bldg.	Total	% Total
HVAC Fan Use	5,403,353	445,829	5,849,182	26.2
Lighting	3,787,403	718,626	4,506,029	20.2
Equipment (general)***	4,603,875	127,342	4,731,217	21.2
			15,086,428	
Cooling (pro-rated; centrifugal allocation only	2,382,785	269,570	2,652,355	11.9
Auxiliaries**			2,777,035	12.4
Transformer & Distr. Losses			1,215,090	5.4
Misc. Electrical*			610,000	2.7
			22,340,908	100.0
			(259,155 MBtu/yr)	
Metered			22,335,600	
% Deviation			<1%	

*Other users drawings power from the WBAMC circuit.
**Central Plant
***Hospital equipment, vacuum and air compressors.

	Fossil Fuel (MBtu/yr)			
	Beaumont Bldg.	Bradley Bldg.	Total	% Total
Heating	52,884	2,654	55,538	31.7
Cooling (pro-rated; absorption chiller allocation)	27,098	3,066	30,164	17.2
Domestic Hot Water			25,200	14.4
Steam Plant Use			5,826	3.3
Kitchen Gas Use			764	0.5
Miscellaneous*			12,000	6.9
Conversion Losses			45,497	26.0
			174,989	100.0
			(169,727 kcf/yr)	
Metered total			179,812	
% Deviation			<2.7%	

*Autoclaves and sterilizers, plus other users drawing power from the WBAMC circuit.

ENERGY CONSERVATION ANALYSIS

Basis for Economic Analysis. The Energy Conservation Investment Program (ECIP) is a Military Construction (MILCON) funded program for facilities within the Department of Defense. The objective of the program is to retrofit existing energy systems and buildings in order to make them more energy efficient and to provide substantial savings in operating costs. To qualifty for ECIP funding, projects must meet the following criteria:

- o Total project cost must be a minimum of $200,000.
- o As a minimum, the SIR for each ECO must be equal to or greater than 1.0.
- o The SIR computation is to be performed using the mode of analysis presented in the National Bureau of Standards (NBS) Handbook 135--Life Cycle Cost Manual for the Federal Energy Management Program.
- o Overall projects, as well as discrete protions of retrofit actions within the project, must be life cycle cost effective.
- o At least 75% of the total discounted life cycle cost savings must result directly from energy cost savings.

Guidance given in the economic analysis of projects for determination of economic feasibility include the following:

- o All SIR calculations and analyses are based on a maximum economic life of 15 years. A 15 year lifetime, the useful life of the retrofit action, or the life of the facility, whichever is less, is to be used.
- o The estimated construction cost, unit cost of energy, and material and labor costs at the installation on the date of the analysis is to be used as the basis for all life cycle cost computations.
- o The estimated investment cost of the retrofit is to be reduced to 90% for the purpose of computing the SIR.

Basis for Energy Cost Savings Benefits. The energy savings for ECOs were determined by using the ESP-II building energy program, and hand calculations where appropriate. The cost savings potential for each ECO is based upon mid-1983 energy costs for WBAMC which were:

Electricity:	
Demand	$15.78/kW
Energy	$0.0484/kWh (includes fuel cost adjustment) ($4.17/Source MBtu)
Natural Gas:	$4.1619/kcf, or $4.037/MBtu

Energy Monitoring and Control System

A feasibility study was performed to determine the energy savings and economic benefits of installing an Energy Monitoring and Control System (EMCS) for electrical and mechanical systems at William Beaumont Army Medical Center (WBAMC) and the Bradley Building (Annex). The general approach was to evaluate as many system modification opportunities as possible before evaluating the EMCS. Thus, the EMCS proposed would not have to be modified after HVAC systems were modified.

The basic EMCS analysis and evaluations which are developed in Technical Manual TM 5-815-2 apply more typically to buildings that have fewer critical needs than a hospital such as WBAMC. Therefore, many of the EMCS functions (especially start/stop functions) cannot be applied. Normally, the start/stop EMCS functions provide the bulk of the energy savings and cost avoidance. In the case of the hospital, the ventilation and recirculation programs and the reset optimization programs will provide the most energy cost savings benefits.

Existing Control Systems

There are two major central control systems presently installed at WBAMC. First, in the main hospital there is an old Johnson Controls central monitoring and control system. This system has basic start/stop capabilities, digital and analog alarm functions, and coil reset control. The system is so old it has numerous failures which are not able to be fixed; Johnson Controls carries the maintenance contract on the system, but is not able to keep it totally operational. Many parts are no longer available because the system has been out of production for many years. This system interfaces to local pneumatic controls on the mechanical equipment of the initial WBAMC installation.

The second control system is a Honeywell Delta 1000 EMCS which serves the new Bradley Annex and the solar energy system installation. This EMCS is a better system than the outdated Johnson Control system, with better control capabilities. However, this system was installed mainly to handle the solar energy system. Custom application software was developed to run the solar energy system, which is not working at the present time. Other mechanical equipment, such as the air handling units, were hardware connected but never programmed with software for any EMCS functions. This means the Delta 1000 is not performing any useful control of the heating, ventilating, and air conditioning systems for the Bradley Building.

The Delta 1000 uses central control computer architecture with all programs memory resident in the central control unit (CCU). Data from control input and output points are sent to a multiplexer panel (MUX), which converts the signals to digital coded signals to communicate with the CCU. It also can demultiplex signals from the CCU to change output control signals. The CCU makes all calculations and logical decision functions necessary to perform monitoring and control of the systems.

"State-of-the-Art" EMCS systems use distributed control architecture, which provides better control reliability by spreading the control processing to additional processing units distributed throughout the facility.

EMCS Option 1, Expand Existing EMCS

The first option analyzed for an EMCS at WBAMC was the replacement of the Johnson Control System by expansion of the existing Honeywell Delta 1000 EMCS. The Delta 1000, which now serves the Bradley Building (Annex), has these EMCS functions already available:

Automatic Functions:	Analog Alarm Scanning Digital Alarm Scanning Time Programs Event Programs
Data Display:	Analog Value Digital Status Alarm Summary
Printout Functions:	Alarm Printouts Alarm Summary Status Summary All Point Log

There are a number of additional EMCS applications programs which would be necessary for this EMCS option. These programs are:

Ventilation and Recirculation Programs:	Economizer cycles
Temperature Reset Optimization Programs:	Resetting room temperatures Chilled water reset Condenser water reset

The advantage of this EMCS option is that most of the system is already installed and is working. To expand the system would require only some additional MUXs, field devices, and some more application programs. In addition, there would be only one EMCS for both WBAMC and the Bradley Building (Annex). Thus, EMCS operators would need to learn only one operating system.

The disadvantage of this system is that it is a central control configuration versus a distributed control configuration.

EMCS Option 2, New Distributed EMCS

The second option to consider for WBAMC is replacement of the old Johnson Control panel with a new distributed type EMCS basically configured as a "medium" size EMCS as described in TM 5-815-2. In this system, the Central Control Unit (CCU) functions as the overall system coordinator, performing

data consolidation, complex calculations, prediction, alarm reporting, and events logging. It would also provide for operator interaction and dynamic process manipulations. Sensed data should be obtained from the Field Interface Devices (FIDs) and Multiplex Panels (MUXs), which are located in the vicinity of the data environment monitored and controlled by the EMCS. The FIDs would control all aspects of their data environments not requiring coordination with the CCU and would be able to function in a limited mode upon failure of the CCU. Failure procedures should be provided to automatically switch the system to manual operation through the FIDs in the event of a CCU failure.

The basic advantage of the distributed EMCS is the added reliability of FID panel control. This is an important consideration in a hospital where there are many critical zones requiring environmental control. One disadvantage to the system is that this could leave WBAMC with two EMCS systems, which would mean personnel would need to learn both EMCS operating systems. In addition, a totally new system would have to be installed and tested with all new central hardware and software.

Analysis Results of EMCS Options

Applying the energy savings benefits of the EMCS functions and the overall system costs of each option, the ECIP life cycle cost analysis of each option was developed. Annual recurring maintenance costs for the EMCS have been included in the economic analysis for each system. The results are summarized as follows:

		Option 1 Expand Existing Honeywell Delta 1000	Option 2 New Distributed EMCS
Investment Cost Estimate (1983$)		440,700	823,400
Annual Energy Savings			
Natural Gas	- MBtu/yr	10,615	10,615
	- 1983 $	42,884	42,884
Electricity	- kWh/yr	1,033,517	1,033,517
	- 1983 $	50,022	50,022
Demand	- kW/yr	168	168
	- 1983 $	2,651	2,651
Total (1983 $)		95,557	95,557
SIR		1.98	1.24

Upgrade Delta 1000 Control of Bradley Building (QRIP Project)

Item 19 on Page 5-4 in the full report points out the possibility of simultaneous heating and cooling between VAV units and window units in the Bradley Building. Also, the VAV units run continuously and could be shut down at night. This project would modify the controls so the Delta 1000 system could solve both problems.

Recently, the facility personnel have started manually shutting down the VAV units during unoccupied hours and shutting off the window units during the summer. This is a good practice and will solve a large part of the problems. However, full savings have been used for this project since personnel changes could negate this policy.

This ECO does not duplicated any of the EMCS option functions.

Heating, Ventilating, and Air Conditioning HVAC Maintenance ECOs

Upgrade VAV Controls in the Bradley Building. At the time of the field survey, it was noted that all of the static pressure sensors for the supply fans (AH 1-6) were improperly located. It was also noted that VAV inlet vane actuators are binding. The static pressure sensors should be relocated to a point closer to the end of the supply duct work, and the inlet vane actuators should be correctly adjusted. The VAV units should then work properly, thus eliminating noisy VAV boxes and saving electrical fan energy.

Upgrade VAV System Economizers in the Bradley Building. An enthalpy economizer cycle uses outside air to satisfy all or a portion of the cooling requirements of the building or zone when the enthalpy (total heat content) of the outside air is less than that of the return air from the enthalpy economizer controls. However, at the time of the survey, these controls were inoperable. By adjusting the controls and replacing necessary parts, the economizer cycle can operate correctly and will save a portion of the cooling energy presently consumed. Converting to a dry bulb economizer would also minimize maintenance costs.

Upgrade VAV Unit Temperature Controls. The VAV units (AH 1-6) in the Bradley Building have a potential for simulatenous heating and cooling. The preheat coil and cooling coil valve controllers are separate controllers sensing the air temperature leaving the cooling coil. If the preheat temperature controller is adjusted to a temperature higher than the cooling coil controller, simultaneous heating and cooling will take place. The preheat coil will add heat, but the cooling coil will immediately remove the heat. The resultant discharge air temperature will be whatever the cooling coil controller is adjusted to. However, much energy will be wasted. A control scheme which prohibits overlap of temperatures should therefore be installed.

Repair Heat Recovery Units. Air handling units 8A, 10A and 10B serving the hospital operating rooms have been equipped with thermal heat recovery units. These units are designed to use warm exhaust air from the space to preheat incoming outside air in the winter and to use cooler exhaust air to help precool outside air being brought in during the summer months. The tilt control distinguishes whether the unit should be tilted for summer operation or winter operation. This control was not functioning on any of the units and is therefore not saving as much energy as it was originally designed to save. By replacing the accessories that enable the tilt control mechanism to work properly, additional energy savings from the recovery units can be realized.

Repair AHU-13 and AHU-14 Cooling Coil Valves. A heating and cooling overlap problem exists on AHU-13 and 14 serving the hospital tower. Measurements during the field survey indicated that the units were cooling 80°F outside air to 57°F, and then reheating that air to 92°F for delivery to the patient rooms, where it was cooled down once again to meet room requirements.

Heating the air to 92°F was explained to be necessary in order to provide heating for some of the older patients. This might not be necessary if the cooling coil was not cooling the air to 57°F at the air handling unit.

The chilled water control valve at the AHUs should be repaired. The supply temperature should then be lowered in the summer to at least 75°F. If complaints of cold rooms continue, cooling valve leakage at the induction units should be investigated and repaired if necessary.

Repair Preheat Controls on AHU-17. During the field survey, the preheat coils on AHU-17 (which serve the research wing) were found to be operating unnecessarily. These coils were heating 73°F outside air to 106°F; it was then necessary for the cooling coil to cool this air to 55°F in order to satisfy space requirements. Repair of the controls will save considerable preheat and cooling energy. This repair will probably also solve some undercooling problems experienced in this building.

Repair Economizer and Reduce OSA. The damper controls on AHUs 8A, 10A, and 10B were inoperative during the field survey. These controls should be repaired and modifications made so that the minimum outside air flow can be reduced. This ECO should be done in conjunction with the other ECOs associated with AHUs 8A, 10A and 10B so that the appropriate design work can be accomplished in one package.

HVAC ECOs

Base Load Centrifugal Chillers. Absorption chillers were used in the past because of the relatively low cost of heat energy which powers the unit. In recent years, the rate of increase in the cost of natural gas has been greater than the rate of increase in the cost of electricity. The rapid rise in the cost of natural gas and the superior operating efficiency of electrically powered chillers can provide economical justification for using an electrically driven unit in lieu of an absorption unit.

The cost to baseload the electric centrifugal chiller(s) would be:

Absorption chiller use =	\$ 63,892
Centrifugal chiller consumption =	\$ 44,827
Centrifugal chiller demand =	\$ 26,700
	\$135,419

Versus \$164,679 for baseloading the absorption chiller.

Savings, then, would be = $29,260/yr, or an 18% reduction in present operating cost.

Since there is no investment cost associated with running one chiller unit before another, and the operating cost savings benefit is readily apparent, all ECOs evaluated have assumed that the electric centrifugal chiller(s) will be base loaded, and that the absorption chiller unit will only operate during the peak cooling season, whenever the cooling load dictates such.

Minimize Outside Air and Add Economizers. A dry bulb economizer uses a fixed temperature to change from 100% outside air to minimum outside air, or modulates in between. The control system should determine what temperature of supply air is being used to satisfy room conditions. If the supply air temperature is greater than room temperature (heating mode), the system should admit the minimum amount of outside air. If the supply air temperature is less than room temperature (cooling mode), the operation should change. If outside air is less than room temperature and less than supply temperature, the system should mix return air and outside air to match supply air temperature requirements. During these conditions, no mechanical cooling is necessary because the outside air temperature is low enough to supply room cooling needs. As the outside air temperature increases to a point above the supply temperature (but still less than room temperature), the system should admit 100% outside air. At this point, some mechanical cooling will become necessary; however, it is still less costly to cool outside air than to cool the hotter inside air. Finally, when the outside air temperature becomes greater than room temperature, the system should reduce outside air volume to the minimum value. Beyond this point, mechanical cooling will provide all of the cooling requirements.

Applicable systems evaluated as part of this ECO are air handling units 1 through 12 and 15 through 17 in the Beaumont Building (hospital).

Convert to Variable Air Volume Systems. Many constant volume air systems can be totally or paritally modified to employ the beneficial characteristics of Variable Air Volume (VAV).
AHUs 1, 3, 4, 5, 9 and 11 were considered for full VAV conversion. This would require modifications at the air handling units for installation of eddy current drives, addition of VAV boxes and reheat coils throughout the spaces, the necessary control changes and sealing off the hot deck at the air handling unit.

AHUs 6, 7 and 12 are VAV systems of a different design. Since the systems are presently single-zone systems, no VAV boxes or reheat coils will be necessary. Changing the diffusers will be the only major work necessary in the occupied spaces for these systems.

Applicable systems evaluated as part of this ECO are AHUs 1, 3, 4, 5, 6, 7, 9, 11, and 12 in the Beaumont Building (hospital).

Convert Mixing Systems to Single-Zone Heat and Cool (SZHC) Systems. Reheat systems cool supply air to a low temperature and then reheat that air to satisfy space conditions. This type of system should be used only when constant dehumidification is required. Separate cooling coils and controls should be provided for each zone. The controls should be sequenced such that either the heating or cooling coil has flow, but not both. This would insure no reheating would be done for a majority of the time. However, for some critical areas, dehumidification will be necessary. For these areas a humidistat should be provided to override the normal cooling valve signal and cause the cooling coil to provide dehumidification as needed. This will, in turn, necessitate reheat to maintain space temperature. Interlocks should be provided so that a leaky humidifier will not cause dehumidification to be required.

Multizone systems mix hot and cold air streams together to produce the appropriate temperature air to condition the zone. These systems are also wasteful and should be replaced with the system described above.

Air Handling Units 8A, 10A and 10B were considered for conversion to a three-deck multizone, or single zone heat and cool systems. Since neither system mixes hot and cold air streams, the energy savings for the El Paso climate are essentially equal (this would not be true in humid climates). The cost estimates were done assuming a three-deck multizone conversion.

Air Handling Units 8, 10, 15, 16 and 17 were considered only for conversion to single zone heat and cool systems. There might be enough room to convert AHUs 8 and 10 to three-deck multizones. However, no cost advantage could be seen.

Applicable systems evaluated as part of this ECO are AHUs 8, 8A, 10, 10A, 10B, 15, 16 and 17 in the Beaumont Building (hospital).

Heat Recovery. Run-around heat recovery units could be installed between outside air and exhaust air ducts on air handling units which require large amounts of outside air. This would preheat the outside air in the winter and precool the outside air in the summer. Savings would accrue from heating and cooling energy reductions.

Applicable systems evaluated as part of this ECO are AHUs 6, 7, 8, 10, 13, and 14 in the Beaumont building. These systems were considered as being the best candidates for heat recovery.

Three-Way Valve Replacement. The chilled water system at WBAMC was originally designed with two-way valves installed on all of the major Air Handling Units. A two-way valve increases (or reduces) water flow in direct proportion to the cooling load. However, a chiller requires nearly a constant flow rate of water for best operation. An existing bypass valve between the supply and return water headers maintains this constant flow. Differential pressure controls the valve so that it bypasses less water as the two-way valves open, and more water as the two-way valves shut.

Three-way valves maintain a constant chilled water flow rate from supply to return piping. Flow is diverted either through the cooling coil or around the cooling coil, depending on the amount of cooling required. When the Bradley Building was built, three-way valves were installed on all of the new Air Handling Units. This upset the hydronic balance in the Beaumont Building, and the chilled water flow rate was no longer proportional to the cooling load. The Bradley Building added a constant 523 gpm of chilled water flow to the system. Each chilled water pump is capable of producing 1,440 gpm of flow. This means that during single chiller operation, when the two-way valves demand more than 917 gpm, the bypass control valve would be completely shut. Any further flow demands by the two-way valves cause system pressure to drop unless an extra chilled water pump was started.

Operating the extra chilled water pump unnecessarily wastes energy. A solution to this problem is to replace the three-way valves in the Bradley Building with two-way valves. One three-way valve (or a small bypass line) should be maintained to insure a small flow through the chilled water piping.

Install Terminal Heating. The induction units in the patient rooms at WBAMC have cooling capability, but no heating capability. The heating is provided by air handling units 13 and 14, which deliver primary air to the induction units in each room.

Delivering cooled primary air is no problem; the induction units just cool the air sufficiently to supply room requirements. However, when heated primary air is supplied (this is the normal operating procedure year-around), the induction units must use cooling energy most of the time to cool the primary air to meet room requirements. The installation of heating in each room would eliminate this wasted energy.

Heating capability would be added to the induction units using existing cooling coils. The result would be a two-pipe induction system with seasonal changeover. The major modification would be done in the fifth floor fan room. Here, a connection would be made between the hot water from the steam converters and the patient room chilled water system. Appropriate isolation valves would be installed so hot water and chilled water would not mix except during the actual changeover operation.

A potential for a comfort problem exists with the two-pipe changeover system, since either heating or cooling could be accomplished by all of the induction units in the patient rooms, but not heating in one and cooling in another.

Short Circuit Exhaust Hoods. Energy consumption can be reduced if the amount of conditioned air that is currently being exhausted by kitchen hoods is reduced. This would be accomplished by providing unconditioned outside air directly to the hood. The existing kitchen hoods would be replaced with auxiliary air hoods capable of supplying outside air to the hood area.

Electrical ECOs

Delamping. Lamps from lighting fixtures can frequently be removed in specific areas of a room. For example, lighting levels in corners of rooms or in areas of rooms which are not used for close work can be reduced. Lighting above desks and work surfaces are the most critical. Lighting requirements determined on an average basis generally result in over-illumination of some parts of a room. A procedure for delamping is presented in Section 5.5.3.1 of the report.

Fluorescent Ballast Monitor. An option to installing phantom tubes is to install a fluorescent monitor* in the circuit of the existing fluorescent system. The fluorescent monitor works by separating the real and reactive current within the fixture so that only the real current is required to maintain ignition of the lamp gases. This increases the efficiency of the load with a lower expenditure of real power.

The monitor can reduce lamp and ballast consumption by 31.4%. With the 31.4% decrease in consumption, a 26% decrease in light output is realized.

This ECO has a simple payback of 2.9 yrs which compares with the simple payback of 1.6 years for phantom tubes (see Section 5.5.3.1 of the report).

High Efficiency Lamps and Ballasts. The following ECOs are recommended for implementation when a lighting component is no longer operative and needs replacement. This includes the replacement of bulbs and ballasts in existing fluorescent lighting fixtures. The ECOs are described below. The results of component replacement shown in Table ES.2, on the following page.

- Replace Standard Fluorescent Lamps with High Efficiency Lamps
  Energy savings can be achieved with minimal incremental cost if standard fluorescent lamps are replaced with reduced wattage lamps on a maintenance replacement basis. Reduced wattage (35W) "Cool-White" lamps are recommended where a 9% illumination level reduction can be tolerated. The 35W "Lite-White" lamps are suggested where present levels of illumination are already at recommended minimums. The standard ballast would remain in use.

- Replace Standard Fluorescent Lamps and Ballasts with High Efficiency Lamps and Ballast
  Existing standard lamps and ballasts in fluorescent fixtures may be replaced with reduced wattage fluorescent lamps and special reduced wattage ballasts. The new combination of lamps and ballasts will operate at reduced wattage and either a reduced illumination ("Cool-White" system) or an increased illumination ("Lite-White" system). The existing lamp and ballast system should be repalced only at the end of its useful life.

* Edison Monitor 21

TABLE ES.2

William Beaumont Army Medical Center
High Efficiency Lamp And Ballast Replacement
Electric Cost, Including Demand = $0.0789/kWh

Fixture Size (feet)	ECO	Description	Annual Operating Hours	Annual Energy Savings kWh	Annual Energy Savings 1983$	Incremental Cost Estimate 1983$	Payback Period (yrs)	Economic Life* (yrs)
4	Lamp replacement (1 tube)	Low wattage "Cool-White" lamp; 9% reduction in illumination	1,000 2,000 4,000	5 10 20	0.39 0.79 1.58	0.55 0.55 0.55	1.4 0.7 0.3	14 7 4
		Low wattage "Lite-White" lamp; 2% reduction in illumition	1,000 2,000 4,000	5 10 20	0.39 0.79 1.56	0.80 0.80 0.80	2.0 1.0 0.5	14 7 4
4	Lamp and ballast Replacement (2 lamps and 1 ballast)	Low wattage "Cool-White" lamps and ballast; 10% reduction in illumination	1,000 2,000 4,000	18 36 72	1.42 2.84 5.68	3.90 3.90 3.90	2.7 1.4 0.7	14 7 4
		Low wattage "Lite-White" lamps and ballast; 4% increase in illumination	1,000 2,000 4,000	14 28 56	1.10 2.21 4.42	4.90 4.90 4.90	4.5 2.2 1.1	14 7 4

* Based on hours of lamp operation

Electric Motor Replacement. When electric motors for commercial and industrial processes or HVAC equipment must be replaced, one of the high efficiency motors should be considered. The savings from reduced operating costs will offset the additional price premium of the improved efficiency motor over the cost of a standard motor. Higher efficiency motors usually exhibit improved power factor characteristics at full and part loads; this can benefit the overall power distribution system at the site. Reduced operating losses, which result in lower operating temperatures, will also increase the expected life of the winding insulation. This ECO would also apply in those instances when new equipment is being installed.

Table ES.3 on the following page shows the minimum operating hours required for a replacement motor to be economically justified; the table also gives the SIR over a 15 year life cycle analysis period.

Lighting Control With Occupancy Sensors. Occupancy sensors use infrared or ultrasonic sensors to determine if a room is occupied. If the room is not occupied, the lights are turned off. A time delay is usually part of the circuit to keep lights from turning off unnecessarily. Since most areas are not continuously occupied even during the work day, some savings can be achieved in the office, clinic and laboratory areas at WBAMC.

A detailed room-by-room occupancy study was not done for this analysis. Therefore, there are probably rooms included which would not be good candidates for this type of control. It is therefore suggested that further study during design is required. However, this analysis is sufficient to demonstrate that for any room where the following assumptions apply, the economics would be valid.

TABLE ES.3

William Beaumont Army Medical Center
Electric Motor Replacement*

Motor HP	KW Saved	Price Premium (1983$)	Annual Operating Hours	Annual (kWh)	Savings (1983$)	Payback On Premium (yrs)	SIR
1.0	0.063	77	2000	126	9.94	7.7	1.4
			4000	252	19.88	3.9	2.8
			8000	504	39.77	1.9	5.7
2.0	0.041	69	2000	82	6.47	10.7	1.0
			4000	164	12.94	5.3	2.1
			8000	328	25.88	2.7	4.1
3.0	0.123	88	2000	246	19.41	4.5	2.4
			4000	492	38.82	2.3	4.9
			8000	984	77.64	1.1	9.7
5.0	0.117	105	2000	234	18.46	5.7	1.9
			4000	468	36.93	2.8	3.9
			8000	936	73.85	1.4	7.7
7.5	0.195	109	2000	390	30.77	3.5	3.1
			4000	780	61.54	1.8	6.2
			8000	1,560	123.08	8.9	12.4
10.0	0.143	154	2000	286	22.57	6.8	1.6
			4000	572	45.13	3.4	3.2
			8000	1,144	90.26	1.7	6.5
15.0	0.446	174	2000	892	70.38	2.5	4.5
			4000	1,784	140.76	1.2	8.9
			8000	3,568	281.52	0.6	17.8
20.0	0.441	197	2000	882	69.59	2.8	3.9
			4000	1.764	139.18	1.4	7.8
			8000	3,528	278.36	0.7	15.6
30.0	0.482	256	2000	964	76.06	3.4	3.3
			4000	1,928	152.12	1.7	6.5
			8000	3,856	304.24	0.8	13.1

* Three-Phase motors, $0.0789/kWh; includes pro-rated demand cost

Turning Off Lights. The question arose during the preliminary review of this study as to whether turning off fluorescent lights intermittently really saves energy, and how long they should be off in order to save energy. The Civil Engineering Laboratory, Naval Construction Battalion Center, at Port Hueneme, California issued a Fact Sheet, No. 050503, on this subject. Their findings were as follows:

> "The total starting current for a two-tube rapid start fluorescent luminaire lasts for about one second. The initial in-rush current lasts for only one-half cycle (1/120 second) and has a peak value about 5 times as large as the steady state peak. This in-rush current does not use a significant amount of energy since it lasts for such a short period of time. Thus, fluorescent lights only have to be turned off for one second in order to save the amount of energy that will be expended when the lights are initially turned on again."

Central Plant ECOs

Boiler Flue Gas Economizers. The present 14,510 lb/hr steam boilers operate with relatively high flue gas temperatures and are not fitted with any flue gas heat recovery systems. A potential exists for recovery and subsequent use of much of the waste heat contained in the flue gas. A flue gas economizer can recover waste heat in the boiler stack and transfer it to the boiler feedwater prior to it entering the boiler.

Boiler Blowdown Heat Recovery. Solids control of the boiler water is accomplished with a continuous blowdown at the waterline, periodic bottom blowdown, and chemicals. The continuous blowdown offers the opportunity to recover heat before it is discharged and transferred to the system make-up water.

Replace Condensate Return System, Absorption Chiller. The trap and duplex condensate pump return system associated with the 600 ton absorption chiller can be replaced with a closed system which would recover flash steam as well as the condensate. This system is generically called a liquid moving condensate handling system which would utilize steam pressure to move the condensate to the deaerator without the use of pumps. This system consists of a receiver (flash tank) with an orifice to an equalizing chamber, and a three-way steam valve operated by a liquid level sensor for the transfer of condensate back to the deaerator.

Cooling Tower "Economizer". A hydronic cooling tower economizer is defined as a system which produces chilled water by direct heat exchange with the cooling tower water in lieu of using a mechanical chiller. This can only be accomplished when the wet bulb temperature of the outside air is below the required chilled water temperature. If the tower is capable of producing a 5°F approach at low loads, and heat exchangers are sized for a 5°F approach, the wet bulb would need to be 10°F lower than the chilled water temperature.

There are systems available which use the tower water directly in the chilled water system, such as a "Strainer Cycle". This would eliminate the need for a heat exchanger in the system and the 5°F approach temperature needed for this heat exchanger. However, this type of system uses a filtering mechanism to clean the tower water; the importance of water treatment and filter backwash is extremely critical for this type of system to operate basically trouble free for years. Also, there is the possibility of obstructing water passages in some of the cooling coils with particles which bypass the filtering device. Therefore, the system described above first with a heat exchanger was considered in this analysis.

Demand Control Using Emergency Diesels. Peak Shaving utilizing the existing emergency diesel generators at WBAMC was investigated for energy cost savings benefits. Both a 750 kW and a 350 kW generator is presently installed, serving the critical loads at the hospital off the EP motor control centers. Since WBAMC is submetered off the main electrical supply from el Paso Electric company, and utility billing is for all of Ft. Bliss, the demand savings and peak shaving is for the entire Ft. Bliss complex.

The electrical peaks for Ft. Bliss occur during the months of June, July and August. A review of the demand readings or these months during 1983 indicated that the peak electrical demand which could be shaved by these two emergency generators varies from month-to-month, but the peak demands can be bracketed as to when they occur. Exactly when the peak occurs varies, due to both facility operation and weather. Based upon this bracketing technique, a reduction in peak demand can occur by running both generators during the following periods.

June	1200-1330, Monday through Friday (1-1/2 hrs per day)
July	0900-1430, Monday through Friday (5-1/2 hrs per day)
August	0830-1430, Monday through Friday (6 hrs per day)
September	1130-1330, Monday through Friday (2 hrs per day)

Therefore, if these units can operate during the operating schedule above for the specific month, and not have a forced outage which would cause the peak demand to be reached (especially during the months of July and August), then peak shaving would result in an anual savings of $116,713 per year (Source energy savings would be 246.8 MBtu/yr), directly for Ft. Bliss, and indirectly for WBAMC, since the utility cost accounting is done on a retioed basis based on usage. Not all cost savings benefits directly affected WBAMC.

Minimize Solar Energy System Cooling Tower Operation. A solar domestic hot water (DHW) system was installed at WBAMC when the Bradley Building was built. This system was not operating during the field survey, and hasn't been for some time. Conversations with the operating personnel at WBAMC confirmed that the cooling tower operates a significant portion of the time whenever the solar energy system is operating. This would indicate (if the system were operating properly) that the solar energy system was oversized for the DHW load requirements at any given time.

Subsequent analysis of the design drawings and calculations indicated that the production capability of the solar energy system as it was originally designed is only about 19% of the average annual domestic water load. This would indicate that the collector array was not oversized but actually undersized, the conclusion being that the cooling tower should run only on rare occasions.

An inspection of the design drawings indicated some possible reasons for the cooling tower to be running almost constantly while the solar energy system is operating. It appears that the solar collectors can operate at only approximately 20% efficiency because of high glycol loop temperatures, and the temperature differential between the two heat exchangers (glycol to water, and water to DHW) is probably less than 4°F. The coldest water of the system is not in contact with the collector loop as it should be for peak operating perfomance and maximum heat transfer.

If the solar system was built to conform with the design drawings, it appears that it will not adequately transfer its total heat capability to the domestic hot water system. Therefore, it is recommended that modifications be made to the system as discussed in Section 5.5.4.6 of the full report and that a change in the operating sequence be made. Further study during design is required to check heat exchanger sizes and pipe sizes. These recommendations are considered the least costly, but not necessarily the optimum from a performance viewpoint.

Building Envelope ECOs

Roof Insulation. Roof insulation will usually conserve both heating and cooling energy. The Air Force Design Manual (AFR 88-15) recommends a roof U-Value of 0.05 Btu/sq.ft.°F for new buildings. The following two methods increasing the insulation to meet this standard were analyzed:

- o Retrofit - new roofing and insulation to be installed and both paid for by the energy savings.
- o Repair - additional insulation would be added during the next major reroofing project. Only the cost of insulation is considered as a capital expense.

Roof insulation was only considered for the research building roof.

Solar Window Films. Solar heat gains during the summer months can be reduced by installing solar reflective window film. Solar film has a shading coefficient of 0.23, which represents an improvement over the present levels of shading at WBAMC. The preliminary results show that the cost of cooling energy saved is not as great as the cost of extra heating energy required in the winter. The demand savings would make the ECO appear to be economically attractive. However, since demand is considered a non-energy savings, this ECO will not qualify under ECIP criteria.

Plastic Strip Doors. Two doorways at WBAMC are used extensively for receiving supplies and removing waste and soiled linen from the premises. These doors are often locked open to facilitate the passage of cargo carts. Consider insulating plastic strip doors to reduce infiltration of unconditioned air into the building.

Shutting Down Systems During Unoccupied Periods. Shutting air handling units off during unoccupied hours is a potential source of energy savings. All of the air handlers in the Bradley Building and AHU-2 in the Beaumont Building are presently being shut down at nights and on weekends. All other air handling units have been considered for night shutdown. However, the following systems have been eliminated from further consideration:

System	Reason
AHU-5	CMS and Radiology Therapy cannot be moved.
AHU-6 and 7	Serves the Tower core area, which is occupied continuously for patient care.
AHU-8, 8A, 10, 10A, 10B	These systems serve Operating and Delivery rooms.
AHU-9	This system supplies the Nurses' Station, which serves the Fourth Floor patient rooms.
AHU-11 and 12	These systems serve the emergency area.
AHU-13 and 14	These systems serve the patient rooms.
AHU-15	This system serves Radiology and Pathology.
AHU-16	This system serves the medical and surgical Intensive Care units.
AHU-17	This unit serves the Research Wing.
AHU-1A	This unit serves the Morgue.
AHU-5A	This unit serves the soiled linen storage area.

This leaves only three systems for further consideration, AHUs 1, 3 and 4 on the first and second Floor.

The spaces served by AHU-1 requiring 24 hour air conditioning are the pharmacy and engineering. Consideration should be given to moving the pharmacy to the third floor (close to the pharmacy on that floor). A remote operating station

for the engineering personnel could also be moved to the third floor close to the security office. These changes would save an estimated 191,318 kWh/yr and $5,556/yr.

The dental clinic (served by AHU-3) on the second floor maintains a small staff at night for emergencies. If the staff could be relocated to another area, AHU-3 could be shut down and then restarted in case of an emergency. This change would save an estimated 342,596 kWh/yr and $9,948/yr.

Two spaces are occupied on the south end of the second floor (served by AHU-4). One is occupied by a duty person in the headquarters area and the other is occupied by a duty person in the Army Nurse Office. Consider relocating these people to other areas. The savings that would result are estimated to be 322,125 kWh/yr and $9,355/yr.

CONCLUSIONS AND RECOMMENDATIONS

It is recommended that the economically feasible ECOs, all of those included in Table ES.4 on the following page be implemented. A graphical representation of the energy consumption picture after implementation of ECOs is shown on Figure ES-1 on page ES-25.

Table ES.5 on page ES-24 lists those ECOs evaluated which are not economically feasible under ECIP criteria at the present time. Should the energy costs at WBAMC and Ft. Bliss increase a significant amount in the future, these ECOs should be re-evaluated.

The present practice of first operating the absorption chiller before the electric centrifugal units and then baseloading the absorption chiller is more costly (on the order of 18%) than utilizing the centrifugal chillers. This is due to the cost of generating steam using natural gas, and the coefficient of the performance of the absorption chiller of 0.69 versus approximately 4.0 for the centrifugal chillers. Therefore, the absorption chiller should be used only after the centrifugal chiller capacity has been fully utilized. This change in operating procedure was assumed to be implemented before ECO analysis was performed.

Table ES.4

WBAMC
Summary of ECO Assessment

ECO Description	System	Energy Savings Electric (MBtu/yr)	Energy Savings Fossil (MBtu/yr)	First Year Savings ($)	Total Investment ($)	Simple Pay Back (yrs)	Total Discounted Savings ($)	SIR
Base Load Centrifugal Chillers		-10,744	24,947	29,259	0			
Peak Shaving with Diesels		2,603	-2,356	116,713	0			
Repair preheat controls	AHU-17	698	1,565	10,538	974	0.1	51,839	53.2
Minimize OSA and add economizer	AHU-6 & 7	-59	1,341	10,853	4,453	0.4	117,150	26.3
Minimize Solar Clg. Tower Operation		758	6,447	31,604	16,895	0.5	383,205	22.7
Repair cooling coil valves	AHU-13 & 14	1,536	3,443	21,025	4,925	0.2	105,197	21.4
Upgrade vav unit temp. controls	AH-1 thru 6	762	1,708	12,616	7,410	0.6	144,844	19.6
Repair Economizer and Reduce OSA	AHU-10B	2	490	2,419	815	0.3	12,058	14.8
Repair Economizer and Reduce OSA	AHU-10A	1	385	1,899	815	0.4	9,468	11.6
Upgrade Honeywell Delta 1000	AH-1 thru 13	2,479	2,222	19,056	20,470	1.1	224,294	11.0
Convert to single zone heat and cool	AHU-10B	437	583	10,467	11,790	1.1	106,956	9.1
Convert to single zone heat and cool	AHU-10A	343	457	8,205	9,776	1.2	83,844	8.6
Convert to single zone heat and cool	AHU-17	313	423	11,084	15,797	1.4	109,268	6.9
Convert to single zone heat and cool	AHU-15	1,586	4,242	22,827	41,877	1.8	279,809	6.7
Three way valve replacement	AH-1 thru 13	1,406	0	8,478	13,340	1.6	88,367	6.6
Convert to variable air volume system	AHU-5	6,394	4,747	52,795	100,485	1.9	597,970	6.0
Convert to single zone heat and cool	AHU-10	829	1,538	22,160	38,855	1.8	229,929	5.9
Convert to single zone heat and cool	AHU-16	1,278	4,499	22,291	49,095	2.2	276,077	5.6
Convert to variable air volume system	AHU-1	5,430	4,528	46,429	94,513	2.0	529,283	5.6
Upgrade VAV controls in Bradley	AH-1 thru 6	560	38	4,625	8,542	1.8	47,103	5.5
Repair Economizer and Reduce OSA	AHU-8A	1	163	791	815	1.0	3,955	4.9
Minimize OSA and add economizer	AHU-9	186	552	4,828	11,223	2.3	53,173	4.7
Minimize OSA and add economizer	AHU-8 & 10	201	934	11,772	25,906	2.2	121,882	4.7
Repair heat recovery units	AHU-10B	0	159	642	1,859	2.9	8,070	4.3
Plastic Strip Doors		3	29	130	392	3.0	1,614	4.1
Convert to single zone heat and cool	AHU-8A	145	194	3,487	9,078	2.6	35,629	3.9
Minimize OSA and add economizer	AHU-11 & 12	540	697	5,575	16,973	3.0	64,902	3.8
Convert to variable air volume system	AHU-11	2,776	2,266	22,781	71,733	3.1	261,205	3.6
Convert to variable air volume system	AHU-3	3,674	4,183	32,917	110,248	3.3	387,454	3.5
Convert to single zone heat and cool	AHU-8	332	616	8,677	28,108	3.2	92,104	3.3
Convert to variable air volume system	AHU-9	2,846	3,738	28,296	108,631	3.8	332,571	3.1
Minimize OSA and add economizer	AHU-17	123	359	1,804	7,263	4.0	22,426	3.1
Upgrade VAV system economizers	AH-1 thru 6	33	12	1,112	1,548	1.4	4,697	3.0
Repair heat recovery units	AHU-10A	35	13	1,310	1,859	1.4	5,516	3.0
Convert to variable air volume system	AHU-4	2,778	3,454	25,399	102,659	4.0	301,669	2.9
Lts. Control With Occupancy Sensors		7,790	-65	52,375	195,379	3.7	537,942	2.8
Minimize OSA and add economizer	AHU-16	313	622	4,947	23,713	4.8	56,234	2.4
Convert to variable air volume system	AHU-6 & 7	1,882	82	10,751	53,984	5.0	113,993	2.1
Boiler flue gas economizers		0	3,451	11,851	77,133	6.5	156,202	2.0
EMCS Option No. 1	All	11,989	10,615	69,084	440,078	6.4	872,718	2.0
Minimize OSA and add economizer	AHU-15	149	232	2,473	14,877	6.0	26,943	1.8
Heat recovery	AHU-13 & 14	165	1,184	9,067	61,217	6.8	101,530	1.7
Replace abs. cond. return system		0	374	1,511	11,342	7.5	18,993	1.7
Install terminal heating	AHU-13 & 14	1,318	4,020	25,324	180,038	7.1	297,330	1.7
Convert to variable air volume system	AHU-12	1,236	87	3,964	35,206	8.9	47,120	1.3
TOTAL		55,126	99,218	806,411	2,032,039	2.5	7,322,538	3.6

Table ES.5

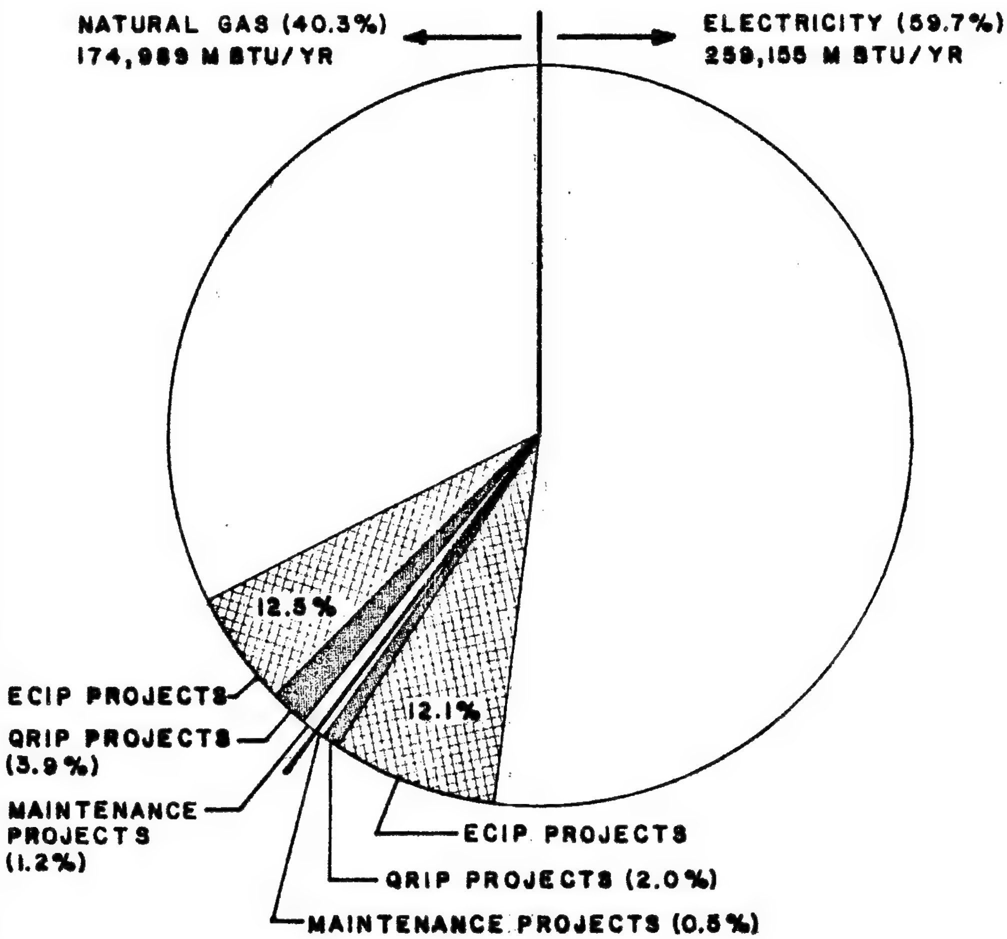
WBAMC
Summary of ECO Assessment
(ECOs with SIR less than 1)

ECO Description	System	Energy Savings Electric (MBtu/yr)	Energy Savings Fossil (MBtu/yr)	First Year Savings ($)	Total Investment ($)	Simple Pay Back (yrs)	Total Discounted Savings ($)	SIR
Cooling Tower Economizer		1,754	0	4,384	73,154	16.7	53,835	0.7
Boiler blowdown heat recovery		0	460	918	23,575	25.7	14,792	0.6
Repair heat recovery units	AHU-8A	0	53	214	1,859	8.7	1,109	0.6
Heat recovery	AHU-8 & 10	77	650	977	62,769	64.2	18,589	0.3
Roof Insulation (Repair)		5	19	113	5,360	47.4	1,326	0.3
Roof Insulation (Retrofit)		5	19	113	8,894	78.7	1,328	0.2
Minimize OSA and add economizer	AHU-1,3,4,&5	400	778	198	211,847	1,069.9	15,842	0.1
Short Circuit Exhaust Hoods		155	942	-727	141,450	-194.6	7,765	0.1
Heat recovery	AHU-6 & 7	120	89	-1,130	73,262	-64.8	-8,078	-0.1
Solar Film		44	-106	-1,124	1,709	-1.5	-4,532	-2.7

FIGURE ES-1

WBAMC

ENERGY CONSUMPTION PICTURE AFTER IMPLEMENTATION OF ECO'S



The results of system air flow measurements and central plant equipment performance measurements identified several deficiencies which should be corrected to improve overall energy use. For example, all but one of the HVAC return air systems are drawing in much more outside air than the present hospital criteria (ETL 1110-3-344 dated 4 October 1983) dictates, thus increasing the cooling load during the summer and the heating load during the winter. Also, an air balance analysis on the various systems and floors of the hospital indicated numerous imbalances between outside air make-up and system exhaust. The systems need to be balanced, and the exhaust systems need to be cleaned.

The combustion efficiency measured for the one boiler which was operating during the field survey was 76%, and the fuel-to-steam efficiency of the boiler plant over the last 26 months was 74%. Oxygen combustion trim control should improve this by 3%, and other ECOs should improve efficiency even further.

An analysis of chiller performance shows that one of the centrifugal units exhibits a pressure drop which is too high, indicating that its evaporator section needs cleaning. Also, excess chilled water flow is inhibiting the chillers from operating at full capacity.

If the solar system was built to conform with the design drawings, it appears that it will not adequately transfer its total heat capability to the domestic hot water system. Therefore, it is recommended that modifications be made to the system as discussed in Section 5.5.4.6 of the full report and that a change in the operating sequence be made. Further study during design is required to check heat exchanger sizes and pipe sizes. These recommendations are considered the least costly, but not necessarily the optimum from a performance viewpoint.

It is further recommended that the solar energy system be maintained in a shutdown mode until these modifications are completed. Precautions should be taken in the interim to ensure that frost damage does not occur and that overheated glycol solution does not turn acidic and cause corrosion damage. In addition, it is recommended that the collectors be shaded if they are to be left inactive.

The EMCS system recommended is the expansion of the existing Honeywell Delta 1000 (in the Bradley Building) to the hospital and adding additional functions. A distributed type EMCS for the hospital is also economically feasible, but not as attractive (SIR of 1.24 versus 1.98 for the expansion of the existing system). Another drawback is that the operators would have to learn and control two systems (one for the hospital and one for the Annex).

This system comprises an additional 275 points; in this size range it is referred to as a small EMCS system, and the Honeywell Delta 1000 does meet Tri-Services specifications. Since there are numerous HVAC system changes involved, these system modifications should be implemented prior to the EMCS project. If the EMCS was designed and installed to control the existing systems, the EMCS would have to be reconfigured to incorporate (for example) VAV systems versus constant volume systems which would now have economizer

cycles where before there were none, single zone heating and cooling systems versus reheat systems, etc. This could be costly, as well as being confusing to operators who would have to relearn the EMCS after each HVAC system conversion.

All of these ECOs, taken collectively, result in an energy savings of 20% in electrical energy use, and 50% in fossil fuel energy use, based on present levels of energy use.

PROJECT DEVELOPMENT

The ECOs which were economically feasible and recommended for implementation were developed into projects for funding purposes as follows:

- o Maintenace Projects - to be implemented through the Ft. Bliss work order system.
- o QRIP Projects - to be implemented through the Productivity Capital Investment Program funding system.
- o ECIP Projects - to be implemented through the MCA Program funding system.

Maintenance projects are those which can be implemented as normal maintenance and repair with the crafts and personnel permanently attached to the Ft. Bliss DEH Office, without undue strain on the workload. Three projects were identified which fell into this category, as listed on Table ES.6. The total estimated labor and material cost for these projects is $6,291. The projects have a combined simple payback period of 0.2 years and an SIR of 24.4. Work Order Forms 4283s were developed for each of these, and were submitted to WBAMC along with the report.

These maintenance projects represent 0.9% reduction in electrical energy use and 2.8% reduction in fossil fuel energy use at WBAMC, based on the present levels of usage.

Table ES.6

WBAMC
Summary of Maintenance Projects

ECO Description	System	Energy Savings Electric (MBtu/yr)	Energy Savings Fossil (MBtu/yr)	First Year Savings ($)	Total Investment ($)	Simple Pay Back (yrs)	Total Discounted Savings ($)	SIR
Repair preheat controls	AHU-17	698	1,565	10,538	974	0.1	51,839	53.2
Repair cooling coil valves	AHU-13 & 14	1,536	3,443	21,025	4,925	0.2	105,197	21.4
Plastic Strip Doors		3	29	130	392	3.0	1,614	4.1
TOTAL		2,238	5,037	31,693	6,291	0.2	158,650	25.2

Three QRIP projects were developed for WBAMC, collectively containing 15 ECOs identified in this study. Each of these three projects meet QRIP criteria. The rationale behind these three projects, shown on Table ES.7 on page ES-30 is the following:

Project No. 1 - Both of these ECOs relate to modifications associated with the existing Honeywell Delta 1000 central control system, even though one is associated with the existing solar energy system and the other with the Omar Bradley Building controls. Since the Delta 1000 system was installed to control both the solar energy system and the HVAC systems in the Bradley Building, this is logical grouping.

Project No. 2 - These four ECOs are all associated with HVAC system modifications to the Bradley Buildng systems. All work associated with these systems should be done together.

Project No. 3 - All nine of the ECOs are associated with AHUs 8A, 10A, 10B, and 15 and are also logical for grouping together and accomplishing at the same time. The designs should be done together to insure that a consistent design is developed.

All of these QRIP projects will require a design effort to detail the actual physical modifications to be done.

These QRIP projects represent an annual energy savings of 2.4% in electrical energy use and an 8.4% reduction in fossil fuel energy use, based on present levels of energy usage. Total investment cost of all three of these QRIP projects is $146,889.

Table ES.7

WBAMC
Summary of ORIP Projects

ECO Description	System	Energy Savings Electric (MBtu/yr)	Energy Savings Fossil (MBtu/yr)	First Year Savings ($)	Total Investment ($)	Simple Pay Back (yrs)	Total Discounted Savings ($)	SIR
ORIP PROJECT NUMBER ONE								
Minimize Solar Cls. Tower Operation		758	6,447	31,604	16,895	0.5	383,205	22.7
Upgrade Honeywell Delta 1000	AH-1 thru 13	2,479	2,222	19,056	20,470	1.1	224,294	11.0
TOTAL		3,237	8,669	50,660	37,365	0.7	607,499	16.3
ORIP PROJECT NUMBER TWO								
Upgrade vav unit temp. controls	AH-1 thru 6	762	1,708	12,616	7,410	0.6	144,844	19.6
Three way valve replacement	AH-1 thru 13	1,406	0	8,478	13,340	1.6	88,367	6.6
Upgrade VAV controls in Bradley	AH-1 thru 6	560	38	4,625	8,542	1.8	47,103	5.5
Upgrade VAV system economizers	AH-1 thru 6	33	12	1,112	1,548	1.4	4,697	3.0
TOTAL		2,762	1,758	26,831	30,840	1.1	285,011	9.2
ORIP PROJECT NUMBER THREE								
Repair Economizer and Reduce OSA	AHU-10B	2	490	2,419	815	0.3	12,058	14.8
Repair Economizer and Reduce OSA	AHU-10A	1	385	1,899	815	0.4	9,468	11.6
Convert to single zone heat and cool	AHU-10B	437	583	10,467	11,790	1.1	106,956	9.1
Convert to single zone heat and cool	AHU-10A	343	457	8,205	9,776	1.2	83,844	8.6
Convert to single zone heat and cool	AHU-15	1,586	4,242	22,827	41,877	1.8	279,809	6.7
Repair Economizer and Reduce OSA	AHU-8A	1	163	791	815	1.0	3,955	4.9
Repair heat recovery units	AHU-10B	0	159	642	1,859	2.9	8,070	4.3
Convert to single zone heat and cool	AHU-8A	145	194	3,487	9,078	2.6	35,629	3.9
Repair heat recovery units	AHU-10A	35	13	1,310	1,859	1.4	5,516	3.0
TOTAL		2,549	6,686	52,047	78,684	1.5	545,305	6.9

Table ES.8 on the following page lists four ECIP projects, composed of 25 ECOs. These are:

Project No. 1 - HVAC system modifications for systems affecting the first four floors of the hospital. These logically should be grouped together for design and construction.

Project No. 2 - Tower (floors 6-12) room systems revisions and central plant modifications.

Project No. 3 - EMCS for WBAMC.

Project No. 4 - Lighting control with Occupancy Sensors.

These ECIP projects represent an annual energy savings of 17.2% in electrical energy use and a 30.3% reduction in fossil fuel energy use, based on present levels of energy usage. Total investment cost in 1983$ for these four ECIP projects is $1,683,530.

Collectively, the baseloading of centrifugal chillers, peak shaving with emergency diesels, maintenance projects, QRIP projects and ECIP projects would reduce present electrical energy use by 20.0% and natural gas usage by 50.3%. The order in which projects are presented is the recommended order of implementation.

Table ES.8

WBAMC
Summary of ECIP Projects

ECO Description	System	Energy Savings Electric (MBtu/yr)	Energy Savings Fossil (MBtu/yr)	First Year Savings ($)	Total Investment ($)	Simple Pay Back (yrs)	Total Discounted Savings ($)	SIR
	ECIP PROJECT NUMBER ONE							
Minimize OSA and add economizer	AHU-6 & 7	-59	1,341	10,853	4,453	0.4	117,150	26.3
Convert to single zone heat and cool	AHU-17	313	423	11,084	15,797	1.4	109,368	6.9
Convert to variable air volume system	AHU-5	6,394	4,747	52,795	100,485	1.9	597,970	6.0
Convert to single zone heat and cool	AHU-10	829	1,538	22,160	38,855	1.8	229,939	5.9
Convert to single zone heat and cool	AHU-16	1,278	4,499	22,291	49,095	2.2	276,077	5.6
Convert to variable air volume system	AHU-1	5,430	4,528	46,429	94,513	2.0	529,283	5.6
Minimize OSA and add economizer	AHU-9	186	552	4,828	11,223	2.3	53,173	4.7
Minimize OSA and add economizer	AHU-8 & 10	201	934	11,772	25,906	2.2	121,882	4.7
Minimize OSA and add economizer	AHU-11 & 12	540	697	5,575	16,973	3.0	64,802	3.8
Convert to variable air volume system	AHU-11	2,776	2,266	22,781	71,733	3.1	261,205	3.6
Convert to variable air volume system	AHU-3	3,674	4,183	32,917	110,248	3.3	387,454	3.5
Convert to single zone heat and cool	AHU-8	332	616	8,877	28,108	3.2	92,104	3.3
Convert to variable air volume system	AHU-9	2,846	3,738	28,296	108,631	3.8	332,571	3.1
Minimize OSA and add economizer	AHU-17	123	359	1,804	7,263	4.0	22,426	3.1
Convert to variable air volume system	AHU-4	2,778	3,454	25,399	102,659	4.0	301,669	2.9
Minimize OSA and add economizer	AHU-16	313	622	4,947	23,713	4.8	56,234	2.4
Convert to variable air volume system	AHU-6 & 7	1,882	82	10,751	53,984	5.0	113,998	2.1
Minimize OSA and add economizer	AHU-15	149	232	2,473	14,877	6.0	26,943	1.8
Heat recovery	AHU-13 & 14	165	1,184	9,067	61,217	6.8	101,530	1.7
Convert to variable air volume system	AHU-12	1,236	87	3,964	35,206	8.9	47,120	1.3
TOTAL		31,385	36,082	339,063	974,939	2.9	3,842,898	3.9
	ECIP PROJECT NUMBER TWO							
Boiler flue gas economizers		0	3,451	11,851	77,133	6.5	156,202	2.0
Replace abs. cond. return system		0	374	1,511	11,342	7.5	18,993	1.7
Install terminal heating	AHU-13 & 14	1,318	4,020	25,324	180,038	7.1	297,330	1.7
TOTAL		1,318	7,845	38,686	268,513	6.9	472,525	1.8
	ECIP PROJECT NUMBER THREE							
EMCS Option No. 1	All	11,989	10,615	69,084	440,078	6.4	872,718	2.0
	ECIP PROJECT NUMBER FOUR							
Lts. Control With Occupancy Sensors		7,790	-65	52,375	195,279	3.7	537,942	2.8

TRAINING

As a part of the overall picture related to this EEAP project for WBAMC, training sessions for the operation and maintenance personnel were held at the conclusion of the project. These training sessions were held in 3 segments, two days each. The overall theme of the training sessions was "Energy Efficiency Through Operation and Maintenance." The annual energy budget for WBAMC is approximately $2.4 million, and with proper care and understanding of the systems and controls, a very obtainable 5% reduction is possible, equivalent to approximately $124,000 per year at mid-1983 energy costs.

A copy of the training schedule presented is given on the following two pages, followed by a table of contents of the manual presented to all attendees. A team of three members of EMC Engineers presented the classroom material and conducted hands-on demonstration training.

WILLIAM BEAUMONT ARMY MEDICAL CENTER

Energy Efficiency Through Operation and Maintenance

Syllabus

First Day

8:30-10:00	Introduction to EMC personel Introduction to the Course Present energy use at WBAMC Review general ECM results Review possible savings Introduction to Pneumatics Questions
10:00-10:15	BREAK
10:15-12:00	Basics of SZHC systems Basics of Reheat systems Basics of Multizone systems Basics of Heat Recovery Questions
12:00-1:00	LUNCH

1:00-2:30	Hands on training
	    Check controls on SZHC
	    Check controls on Reheat
	    Check controls on Multizone
	    Check damper leakage on Multizone
	    Check Heat Recovery controls
	Questions

2:30-2:45	BREAK
2:45-4:00	Basics of Induction Systems Basics of VAV Systems Basics of Economizers Questions

WILLIAM BEAUMONT ARMY MEDICAL CENTER

Energy Efficiency Through Operation and Maintenance

Syllabus

Second Day

8:00-10:00	Hands-On training Check controls on Induction air handler Check VAV controls Check Economizer controls Questions
10:00-10:15	BREAK
10:15-12:00	Solar system basics Energy conservation retrofits Questions
12:00-1:00	LUNCH
1:00-2:30	Chiller basics Boiler basics Electrical distribution Lighting Questions
2:30-2:45	BREAK
2:45-4:00	Hands on training Boiler controls Chiller controls Solar Questions and Review

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